Toxin Reviews

ISSN: 1556-9543 (Print) 1556-9551 (Online) Journal homepage: http://www.tandfonline.com/loi/itxr20

Risk of morbidity attributed to ambient PM_{10} in the western cities of Iran

Mohammad Daryanoosh, Gholamreza Goudarzi, Rajab Rashidi, Fariba Keishams, Philip K. Hopke, Mohammad Javad Mohammadi, Heshmatollah Nourmoradi, Pierre Sicard, Afshin Takdastan, Mehdi Vosoughi, Mohammad Veysi, Mahsa Kianizadeh & Yusef Omidi Khaniabadi

To cite this article: Mohammad Daryanoosh, Gholamreza Goudarzi, Rajab Rashidi, Fariba Keishams, Philip K. Hopke, Mohammad Javad Mohammadi, Heshmatollah Nourmoradi, Pierre Sicard, Afshin Takdastan, Mehdi Vosoughi, Mohammad Veysi, Mahsa Kianizadeh & Yusef Omidi Khaniabadi (2017): Risk of morbidity attributed to ambient PM_{10} in the western cities of Iran, Toxin Reviews, DOI: 10.1080/15569543.2017.1370602

To link to this article: http://dx.doi.org/10.1080/15569543.2017.1370602

Published online: 11 Sep 2017.

TOXIN REVIEWS, 2017
https://doi.org/10.1080/15569543.2017.1370602

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Check for updates

Risk of morbidity attributed to ambient PM_{10} in the western cities of Iran

Mohammad Daryanoosh[a,b], Gholamreza Goudarzi[a,c], Rajab Rashidi[d], Fariba Keishams[e], Philip K. Hopke[f,g], Mohammad Javad Mohammadi[h], Heshmatollah Nourmoradi[i,j], Pierre Sicard[k], Afshin Takdastan[c], Mehdi Vosoughi[l], Mohammad Veysi[m], Mahsa Kianizadeh[n] and Yusef Omidi Khaniabadi[a,o]

[a]Air Pollution and Respiratory Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; [b]Health Center of Hendijan, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; [c]Environmental Technologies Research Center (ETRC), Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; [d]Nutrition Health Research Center, Department of Occupational Health Engineering, School of Health, Lorestan University of Medical Sciences, Khorramabad, Iran; [e]Department of Environmental Health Engineering, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran; [f]Department of Public Health Sciences, University of Rochester School of Medicine and Dentistry, Rochester, NY, USA; [g]Center for Air Resources Engineering and Science, Clarkson University, Potsdam, NY, USA; [h]Abadan School of Medical Sciences, Abadan, Iran; [i]Biotechnology and Medical Plants Research Center, Ilam University of Medical Sciences, Ilam, Iran; [j]Department of Environmental Health, School of Health, Ilam University of Medical Sciences, Ilam, Iran; [k]ACRI-HE, Sophia-Antipolis, France; [l]Department of Environmental Health, School of Public Health, Ardabil University of Medical Sciences, Ardabil, Iran; [m]Industrial Relation Office, Deputy of Research Affair, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; [n]Department of Environmental Health, Shahrekord University of Medical Sciences, Shahrekord, Iran; [o]Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

ABSTRACT

The incidence of hospitalizations due to cardiovascular (HACVD) and respiratory diseases (HARD) associated with PM_{10} was assessed with AirQ2.2.3. Daily PM_{10} data were used to this purpose. The results showed that 8.2% (95% CI: 5.6–11.4%), 7.2% (95% CI: 4.9–10.1%), and 4.4% (95% CI: 3.0–6.3%) of HACVD and 7.3% (95% CI: 4.5–10%), 6.4 (95% CI: 4.0–8.8%), and 3.9% (95% CI: 2.4–5.4%) of HACVD in the cities of Ahvaz, Khorramabad and Ilam were attributed to PM_{10}, respectively. Governmental authorities need to act to control the dust hazard by spreading mulch and developing green space using vegetation amenable to the local climate.

ARTICLE HISTORY
Received 30 April 2017
Revised 14 August 2017
Accepted 19 August 2017

KEYWORDS
PM10; HACVD; HARD; hospital admission; Iran

1. Introduction

Air pollution due to industrialization and urbanization is one of the major environmental issues in the current century (Guo *et al.* 2010, Goudie 2014, Nourmoradi *et al.* 2016, Khaniabadi *et al.* 2017b, 2017e). Epidemiological studies have shown that chronic and acute health problems attributed to outdoor air pollution include hospitalizations for respiratory, cardiopulmonary, and cardiovascular diseases and related mortality (Khaniabadi *et al.* 2017a, 2017d).

Among the ambient atmospheric pollutants, particulate matter (PM) produces the most harmful effects on human health (Mentese *et al.* 2012). Many studies have reported strong statistical associations between PM and respiratory diseases, pulmonary damage, and mortality.

Particulate matter with an aerodynamic diameter equal to or less than 10 µm is PM_{10} (Menetrez *et al.* 2009, Mirhosseini *et al.* 2013, Geravandi *et al.* 2017, Goudarzi *et al.* 2017). Short-term exposure to PM_{10} can irritate the lungs and possibly cause immune responses, lung constriction, shortness of breath and cough. Long-term exposure to PM_{10} may result in cancer and premature mortality (Goudie and Middleton 1992, 2001, Khaniabadi *et al.* 2017c). In addition to the health outcomes resulting from increase pollution from industrialization and urbanization, increasingly frequent natural dust events have affected various geographical areas in recent years, especially in the Middle East (Goudie 2014, Khaniabadi *et al.* 2017c). The regions of south, west, and southwest of Iran have been exposed to Middle Eastern Dust (MED) storms, especially those storms coming from the Arabian Peninsula, Kuwait, and Iraq. Ahvaz, Khorramabad, and Ilam cities are located in western Iran, and these cities have been exposed to high PM_{10} concentrations as a result of these MED events. The dust events have caused thousands of hospitalizations due to cardiovascular and respiratory diseases (Goudie and Middleton 1992, 2001, Guo *et al.* 2010, Neisi et al. 2017a,

CONTACT Yusef Omidi Khaniabadi yusefomidi@yahoo.com Air Pollution and Respiratory Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Nourmoradi *et al.* 2016, Khaniabadi *et al.* 2017a, 2017c, 2017d). Shahsavani *et al.* (2012) found that high concentrations of PM were related to adverse human health outcomes during dust event days in Ahvaz, Iran (Shahsavani *et al.* 2012). Kwon *et al.* (2002) argued that there is a statistically significant correlation between dust storms and death associated with cardiovascular and respiratory diseases in Seoul, Korea (Kwon *et al.* 2002), while (Meng and Lu 2007) evaluated the relationship between dust events and hospital admissions due to respiratory and cardiovascular diseases, pneumonia, and hypertensions in China.

The objective of this study was to estimate the health effects of MED storms on hospital admissions due to cardiovascular and respiratory diseases in Ahvaz, Khorramabad, and Ilam using the $AirQ_{2.2.3}$ model in 2016.

2. Materials and methods

2.1. Study area

Ahvaz (31°20′N, 48°40′E), Khorramabad (33°29′N, 48°21′E), and Ilam (33°36′N, 46°36′E) are the capital cities of Khuzestan, Lorestan, and Ilam provinces situated in western Iran (see Figure 1) (Khaniabadi et al. 2017a, 2017b, Mohammadi et al. 2017, Neisi et al. 2017b). They have a total population of 1,300,000, 540,000, and 172,000 persons, respectively. Goudie reported that Khorramabad is the nineteenth most polluted city in the world in terms of annual average PM_{10} concentrations (Goudie 2014).

2.2. Air sampling

Air pollution-monitoring sites established by the Environmental Protection Agencies (KEPA) of Ahvaz, Khorramabad, and Ilam, and they maintained and operated them. PM_{10} concentrations were measured using beta attenuation monitors (BAMs). One-year data of PM_{10} concentrations from January to December 2016 were measured. Hourly PM_{10} concentrations were measured and 24-h PM_{10} concentrations were processed to provide the input for the health effects model. We estimated hospital admissions resulting from cardiovascular and respiratory diseases caused by exposure to particulate matter (PM_{10}) using the Air Quality Health Impact Assessment model (AirQ2.2.3). AirQ was developed by the WHO European Center for Environment and Health based on multiple peer-reviewed studies (Atkinson and Anderson 1997, Burret and Doles 1997, Touloumi 1997, Khaefi *et al.* 2017). AirQ is a tool, used in many previous studies (Geravandi *et al.* 2017, Khaniabadi *et al.* 2017a, 2017b, 2017d, 2017e), to assess the relationship between air pollutants concentration and health outcomes in a defined area during a given period using ambient monitoring data. The model uses dose–response function based on epidemiological studies (Khaniabadi *et al.* 2017a, 2017d).

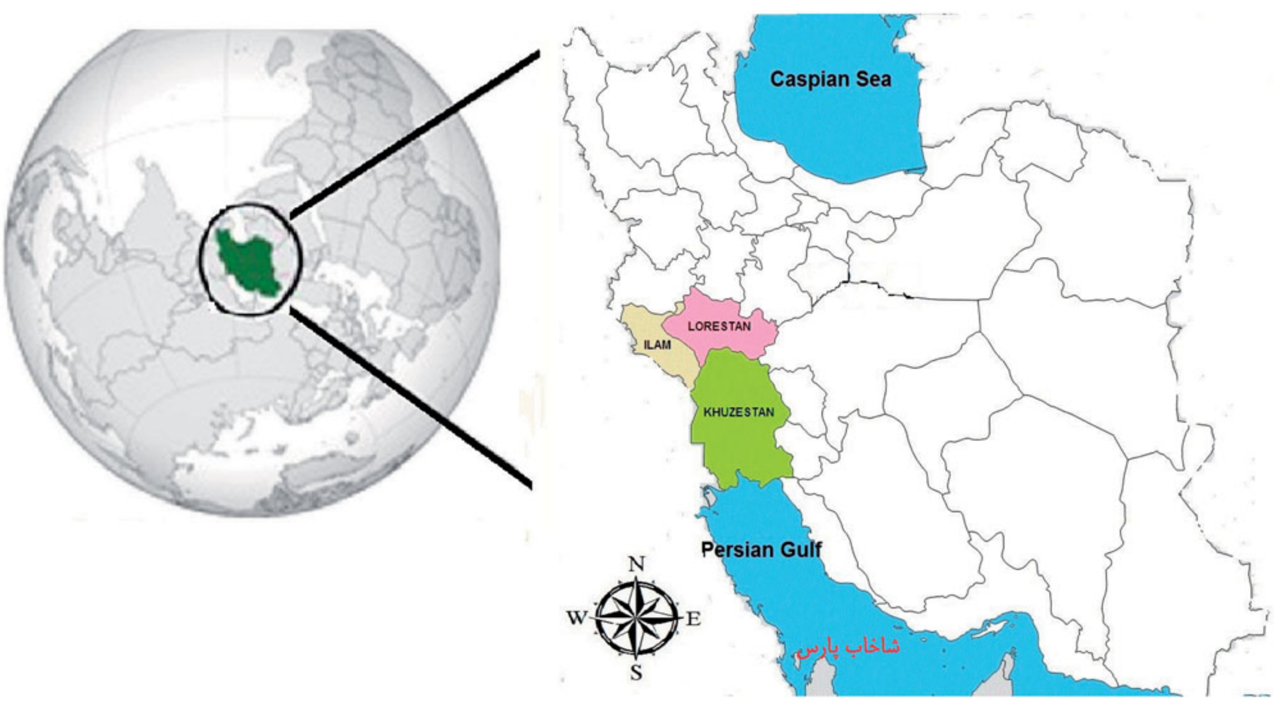

Figure 1. Location of Khuzestan, Lorestan, and Ilam provinces in Iran.

Table 1. Relative risk (95% CI) and baseline incidence used for investigating the health effects of PM_{10}.

Health effect	BI[a]	RR[b] (95% CI) per 10 $\mu g/m^3$
HACVD[d]	1260	1.008 (1.005–1.01)[c] (Khaniabadi *et al.* 2017c)
HARD[e]	436	1.009 (1.006–1.013) (Goudarzi *et al.* 2017, Jeong 2013)

[a]Baseline incidence.
[b]Relative risk.
[c]Confidence interval.
[d]Hospital admissions for cardiovascular diseases.
[e]Hospital admissions for respiratory diseases.

Table 2. Annual and seasonal concentrations of PM_{10} ($\mu g/m^3$).

Time	Ahvaz	Khorramabad	Ilam
Annual			
Average ($\mu g/m^3$)	534.8	80.6	60.5
Maximum ($\mu g/m^3$)	6041.0	476.0	688.0
Summer			
Average ($\mu g/m^3$)	257.6	102.9	69.5
Maximum ($\mu g/m^3$)	1378.7	376.0	513.0
Winter			
Average ($\mu g/m^3$)	901.9	58.3	51.5
Maximum ($\mu g/m^3$)	6041.0	476.0	688.0

2.3. Health impacts

The PM_{10} concentration data from January to December 2016 (12 months) were obtained from the environment protection agencies of each city. In epidemiological studies, particularly in AirQ, the input parameters related to health are relative risk (RR) and baseline incidence (BI). The RR is the possibility of developing an illness resulting from exposure to a pollutant. The RR and BI per 100,000 individuals associated with different types of mortality and morbidity are presented in Table 1. The RR and BI values were obtained from the data provided with the AirQ2.2.3 software. In this software, the health impact assessment of air pollutants is achieved by calculation of the attributable proportion (AP), which explains the portion of health impacts that occur for certain people due to contact with air pollutants (Khaniabadi *et al.* 2017c, 2017f). The AP was calculated using the following equation:

$$AP = \sum \Big([RR(c) - 1] \times P(c)]\Big) / \sum [RR(c) \times P(c)] \quad (1)$$

where AP and RR(c) are the AP of the health impact and RR for a certain health impact in the group c of exposure. Also, P(c) is the fraction of the target population in group c of exposure. The amount attributable to the population exposure was calculated using Equation (2) assuming that the baseline frequency of the specific health effect in the studied population is known.

$$IE = I \times AP \quad (2)$$

where IE and I are the rate of the health impact attributable to the contact and the baseline frequency of the health impact in the population, respectively. Then, given a population size, the total number of excess cases attributable to the exposure is specified by Equation (3).

$$NE = IE \times N \quad (3)$$

where NE is the number of adverse health outcomes attributed to the exposure and *N* is the total number of exposed residents. The mean daily concentrations of PM_{10} were used in the study. The number of hospital admissions for cardiovascular disease (HACVD) and respiratory disease (HARD) were estimated by RR and BI using the $AirQ_{2.2.3}$ model.

Following the International Classification of Diseases Tenth Revision (ICD-10), hospital admissions due to cardiovascular diseases (HACVD) and due to respiratory diseases (HARD) including (i) total respiratory diseases (J00–99), and the subgroups of respiratory disease: upper respiratory tract infection (J00–06) and pneumonia (ICD-10: J12–18); (ii) total cardiovascular diseases (I00–51), and the subgroups: ischemic heart disease (I20–25) and hypertension (I10–I15) were estimated in these analyses.

3. Results and discussion

3.1. PM_{10} concentrations

Table 2 shows the annual and seasonal average 2016 PM_{10} concentrations. The maximum seasonal PM_{10} concentrations in Ahvaz, Khorramabad, and Ilam (6041, 476, and 688 $\mu g/m^3$, respectively) were observed during the winter. Shahsavani *et al.* (2012) reported that the maximum PM_{10} concentration was highest in the summer in Ahvaz.

The maximum average seasonal PM_{10} concentration in Ahvaz was 901.9 $\mu g/m^3$ and occurred in winter. For Khorramabad (102.9 $\mu g/m^3$) and Ilam (62.5 $\mu g/m^3$), the highest seasonal averages occurred in summer. The annual average PM_{10} concentration in Ahvaz exceeded the National Ambient Air Quality Standard (NAAQS) (150 $\mu g/m^3$). However, the annual average PM_{10} values in Khorramabad and Ilam were within the air quality guideline values prescribed by the NAAQS.

Higher PM_{10} values in Ahvaz were due to more frequent MED storms compared to the other cities (Shahsavani *et al.* 2012). MED storms are the primary cause of dust events in Ahvaz. Moreover, Ahvaz is more populous and industrialized than the other cities.

Therefore, other sources of pollution including transportation (vehicles) and industries also may also contributed to its high PM_{10} concentrations.

3.2. Person-days

Figure 2 illustrates the percentage of days that people in Ahvaz, Khorramabad, and Ilam were exposed to different concentrations of PM_{10} from MED storms during 2016. The highest percentage of exposure to PM_{10} in Ahvaz, Khorramabad, and Ilam occurred on days with concentrations in the intervals of 130–139, 60–69, and 40–49 $\mu g/m^3$ with percentages of 13.3, 9.5, and 20.2, respectively. In another study, the maximum person-days of exposure in Makkah, Saudi Arabia were in the PM_{10} concentrations range of 200–249 $\mu g/m^3$ (Habeebullah 2013). The maximum percentage of the days that people in Mazzano and Rezzato (Italy) were exposed to different PM_{10} levels was found to be in the concentration interval of 40–49 $\mu g/m^3$ (Fattore *et al.* 2011), which is similar to the present study for Ilam.

3.3. Health impact assessment

The results of the $AirQ_{2.2.3}$ model analysis of PM_{10} concentrations with 95% confidence intervals (95% CI) are shown in Table 3.

The cumulative number of excess cases for HACVD and HARD for BI values of 1260 and 436 were estimated for Ahvaz to be 508 and 1319 cases. For the other cities, Khorramabad had 144 and 372 cases, and Ilam had 66 and 170 cased based on total populations of 1,300,000, 540,000, and 172,000 persons, respectively. For comparison, in another study by AirQ, the number of excess cases of HARD and HACD due to PM_{10} exposure in Tallinn (Estonia) were estimated to be 71 and 204 persons (CI) (Orru *et al.* 2011).

The number of excess cases of HACVD and HARD associated with PM_{10} concentrations during 2016 are presented in Figure 3. This figure illustrates diagrams based on the number of each health outcome and the number of estimated cases for the central RR (50%) versus PM_{10} concentration, respectively.

In Ahvaz, Khorramabad, and Ilam, 246, 15.2, and 67.3 cases of HACVD per 10^5 persons and 638, 39.2, and 174.4 of HARD per 10^5 persons can be attributed to the PM_{10} concentrations above 150 $\mu g/m^3$, respectively. For each increase of 10 $\mu g/m^3$ in concentration of PM_{10}, the risk of HACVD and HARD increases by about 0.8 and 0.9%, respectively. These results also show that 8.2% (95% CI: 5.6–11.4%), 7.2% (95% CI: 4.9–10.1%), and 4.4% (95% CI: 3.0–6.3%) of HACVD and 7.3% (95% CI: 4.5–10%), 6.4 (95% CI: 4.0–8.8%), and 3.9% (95% CI: 2.4–5.4%) of HACD in Ahvaz, Khorramabad, and Ilam, respectively, were related to PM_{10} concentrations exceeding 10 $\mu g/m^3$, respectively. In addition, about 90%, 94%, and 97.6% of the HACVD

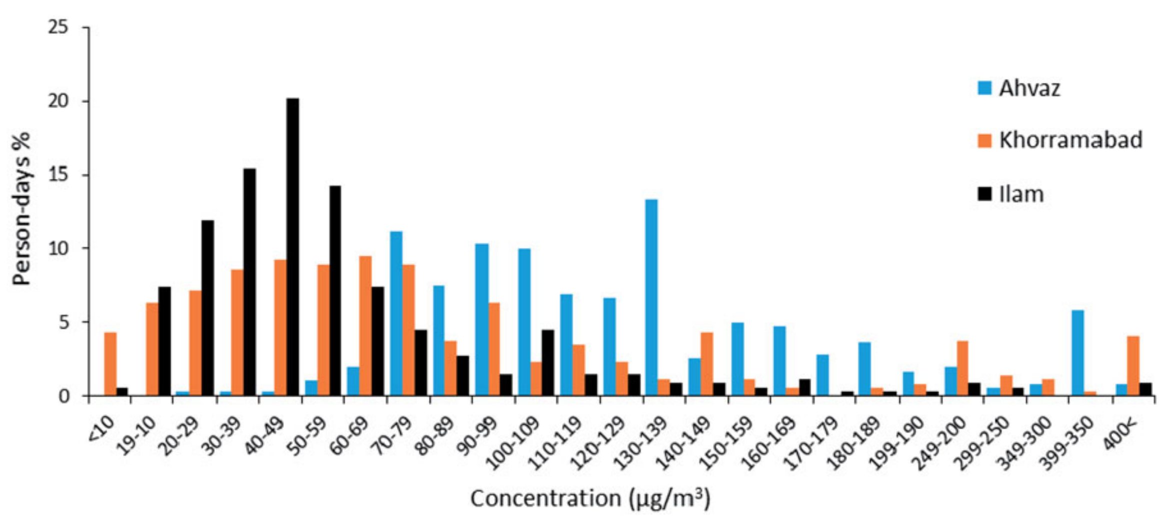

Figure 2. Percentage of days that people in Ahvaz, Khorramabad, and Ilam were exposed to PM_{10} as a result of dust storms.

Table 3. Relative risk, baseline incidence, attributable proportion and cumulative number of excess cases in 95% confidence intervals (95% CI).

	Estimated AP (%)					Number of excess persons		
Parameter	Ahvaz	Khorramabad	Ilam	RR (per 10 $\mu g/m^3$)	BI	Ahvaz	Khorramabad	Ilam
HACVD	8.2 (5.6–11.4)	7.2 (4.9–10.1)	4.4 (3.0–6.3)	1.008 (1.005–1.01)	1260	508 (351–700)	144 (98–201)	66 (45–93)
HARD	7.3 (4.5–10.0)	6.4 (4.0–8.8)	3.9 (2.4–5.4)	1.009 (1.006–1.013)	436	1319 (823–1779)	372 (229–507)	170 (104–234)

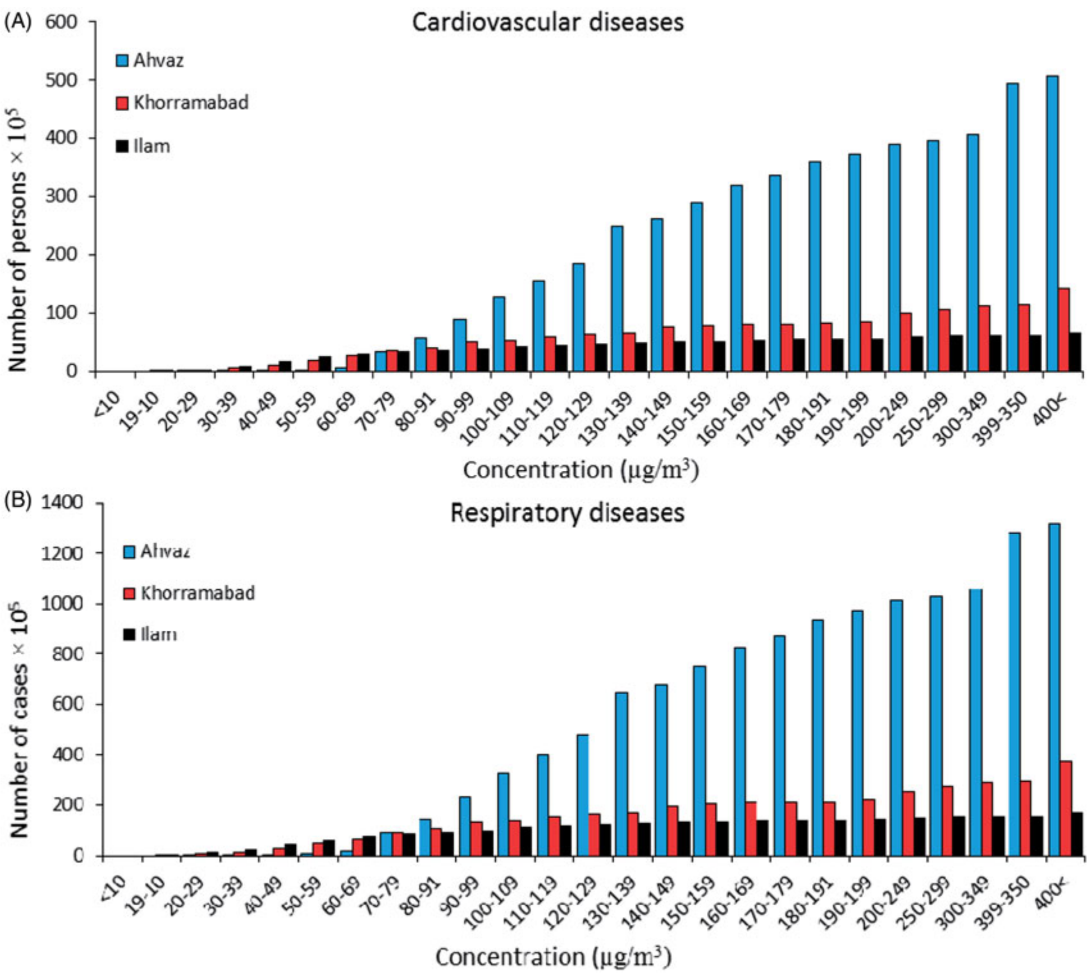

Figure 3. Cumulative number of cases HACVD and HARD versus PM_{10} in Ahvaz, Khorramabad, and Ilam cities.

and HARD occurred on days with PM_{10} concentrations less than 200 μg/m^3 in Ahvaz, Khorramabad, and Ilam, respectively.

In another study, Goudarzi *et al.* (2017) reported that the number of HARD and HACVD decreased in Kermanshah, in 2014 to 184 and 476 persons compared with 2011 (Zallaghi 2014).

The estimated HACVD and HARD incidences due to exposure to PM_{10} were in the order of Ahvaz > Khorramabad > Ilam. These differences can be attributed to the varying geographic conditions, population ratios, climates, and the rates of development of these cities. Furthermore, Ahvaz, located in a desert area and more subjected to MED storms, has great air pollution (non-attainment of NAAQS). Thus, the population was subjected to higher exposures that produce higher rates of hospitalizations than in the other cities.

4. Conclusions

A health impact assessment of particulate matter (PM_{10}) exposure in Ahvaz, Khorramabad, and Ilam showed that adverse health effects in these cities were likely to have resulted from higher than average PM_{10} concentrations on dusty days driven by MED storms. Given the estimated cardiovascular and respiratory mortality associated with PM_{10}, cardiovascular mortality had a larger main role in the total mortality resulting from PM. To decrease the health impacts of PM, health training should be conducted to encourage the public, especially people with chronic lung and heart diseases, and other susceptible individuals such as the elderly and children to reduce their activities on the dusty days. Moreover, efforts should be conducted by the governments to control of dust by spreading mulch and the development of green space particularly using vegetation amenable to the local climate.

Acknowledgements

The authors wish to thank the Ahvaz Jundishapur University of Medical Sciences for financial supports (Grant No.: APRD-9608).

Disclosure statement

The authors have no conflicts of interest.

Funding

The authors wish to thank the Ahvaz Jundishapur University of Medical Sciences for financial supports [Grant No. APRD-9608].

References

Atkinson, R. and Anderson, H., 1997. Daily time series for cardiovascular hospital admissions and previous day's air pollution in London, UK. *Occupational and environmental medicine*, 54, 535–540.

Burret, R. and Doles, R., 1997. Association between ambient carbon monoxide levels and hospitalization for congestive heart failure in the elderly in 10 Canadian cities. *Epidemiology*, 8, 162–167.

Fattore, E., *et al*., 2011. Human health risk in relation to air quality in two municipalities in an industrialized area of Northern Italy. *Environmental research*, 111, 1321–1327.

Geravandi, S., *et al*., 2017. A comparative study of hospital admissions for respiratory diseases during normal and dusty days in Iran. *Environmental science and pollution research*, 24, 18152–18159.

Goudarzi, G., *et al*., 2017. Health risk assessment of exposure to the Middle-Eastern Dust storms in the Iranian megacity of Kermanshah. *Public health*, 148, 109–116.

Goudie, A. and Middleton, N., 1992. The changing frequency of dust storms through time. *Climate change*, 20, 197–225.

Goudie, A. and Middleton, N., 2001. Saharan dust storms: nature and consequences. *Earth-science reviews*, 56, 179–204.

Goudie, A.S., 2014. Desert dust and human health disorders. *Environment international*, 63, 101–113.

Guo, Y., *et al*., 2010. The relationship between particulate air pollution and emergency hospital visits for hypertension in Beijing, China. *Science of the total environment*, 201, 4446–4450.

Habeebullah, T., 2013. Health Impacts of PM10 Using AirQ2.2.3 Model in Makkah. *Journal of basic & applied sciences*, 9, 259–268.

Jeong, S., 2013. The impact of air pollution on human health in Suwon City. *Asian journal of atmospheric environment*, 7, 227–233.

Khaefi, M., *et al*., 2017. Association of particulate matter impact on prevalence of chronic obstructive pulmonary disease in Ahvaz, southwest Iran during 2009–2013. *Aerosol and air quality research*, 17, 230–237.

Khaniabadi, Y.O., *et al*., 2017a. Impact of Middle Eastern Dust storms on human health. *Atmospheric pollution research*, 8, 606–613.

Khaniabadi, Y.O., *et al*., 2017b. Acute myocardial infarction and COPD attributed to ambient SO_2 in Iran. *Environmental research*, 156, 683–687.

Khaniabadi, Y.O., *et al*., 2017c. Hospital admissions in Iran for cardiovascular and respiratory diseases attributed to the Middle Eastern Dust storms. *Environmental science and pollution research*, 24, .16860–16868.

Khaniabadi, Y.O., *et al*., 2017d. Exposure to PM10, NO2, and O3 and impacts on human health. *Environmental science and pollution research*, 24, 2781–2789.

Khaniabadi, Y.O., *et al*., 2017e. Cardiopulmonary mortality and COPD attributed to ambient ozone. *Environmental research*, 152, 336–341.

Khaniabadi, Y.O., *et al*., 2017f. Human health risk assessment due to ambient PM10 and SO2 by an air quality modeling technique. *Process safety and environmental protection*, [Epub ahead of print]. doi: 10.1016/j.psep.2017.07.018

Kwon, H.J., *et al*., 2002. Effects of the Asian dust events on daily mortality in Seoul, Korea. *Environmental research*, 90, 1–5.

Menetrez, M., *et al*., 2009. An evaluation of indoor and outdoor biological particulate matter. *Atmospheric environment*, 43, 5476–5483.

Meng, Z. and Lu, B., 2007. Dust events as a risk factor for daily hospitalization for respiratory and cardiovascular diseases in Minqin, China. *Atmospheric environment*, 41, 7048–7058.

Mentese, S., *et al*., 2012. Seasonal and spatial variations of bioaerosols in indoor urban environments, Ankara, Turkey. *Indoor and built environment*, 21, 797–810.

Mirhosseini, S.H., *et al*., 2013. Analysis of particulate matter (PM10 and PM2.5) concentration in Khorramabad city. *International journal of environmental health engineering*, 2, 1–4.

Mohammadi, M., *et al*., 2017. Road traffic noise in urban environments in Ahvaz city, Iran. *Fresenius environmental bulletin*, 26, 2747–2752.

Neisi, A., *et al*., 2017a. Comparison of normal and dusty day impacts on fractional exhaled nitric oxide and lung function in healthy children in Ahvaz, Iran. *Environmental science and pollution research*, 24, 12360–12371.

Neisi, A., *et al*., 2017b. Concentration of air pollutants as toxic matter in urban and rural areas of Ahvaz. *Toxin reviews*, [Epub ahead of print]. doi: 10.1080/15569543.2017.1337796

Nourmoradi, H., *et al*., 2016. Air quality and health risks associated with exposure to particulate matter: a cross-sectional study in Khorramabad, Iran. *Health scope*, 5, e31766.

Orru, H., *et al*., 2011. Health impacts of particulate matter in five major Estonian towns: main sources of exposure and local differences. *Air quality, atmosphere & health*, 4, 247–258.

Shahsavani, A., *et al*., 2012. The evaluation of PM10, PM2.5, and PM1 concentrations during the Middle Eastern Dust (MED) events in Ahvaz, Iran, from April through September 2010. *Journal of arid environments*, 77, 72–83.

Touloumi, G., 1997. Short-term effects of ambient oxidant exposure on mortality: a combined analysis within the APHEA project. Air Pollution and Health: a European Approach. *American journal of epidemiology*, 146, 177–185.

Zallaghi, E., 2014. Assessment of health impacts attributed to PM10 exposure during 2011 in Kermanshah City, Iran. *Journal of advances in environmental health research*, 2, 242–250.